# Using Workflow Technology to Manage Flexible e-Learning Services

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**ABSTRACT**

Workflow technology provides a suitable platform to define and manage the coordination of business process activities. We introduce a flexible e-learning environment – called Flex-eL – that has been built upon workflow technology. The workflow functionality of Flex-eL manages the coordination of learning and assessment activities of the course process between students and teaching staff. It provides a unique environment for teachers to design and develop process-centric courses and to monitor student progress. It allows students to learn at their own pace while observing the learning guidelines and checkpoints modeled into the course process by teaching staff. We also report on the successful deployment of the concept and system for university courses and our experiences from the implementation.

**Keywords**

Workflows, e-Learning, Flexible learning environment

## 1. Introduction

In the past few years, the use of information technology has increased substantially in the education domain. At the same time, expectations of students and teachers from the technology supported education systems have increased as well. More and more mature age, part time, and international students with a wide variety of education, professional and cultural backgrounds are engaging in education and training to support their career goals. They are increasingly distributed globally and have very diverse learning needs and learning styles. Flexible e-Learning solutions are required to meet their needs. The challenge is not to use new technologies to re-create traditional education systems, but rather create new learning environments, providing improvements to both teachers and students, and enhance the quality of education Marjanovic & Orlowska (2000), Sadiq & Orlowska (2001).

Through flexible e-learning systems students would receive education – anytime and anywhere – that matches their own pace and learning style. The idea of high quality learning experience is not to move from teacher-centered learning to technology-centered learning but rather to student-centered learning. Learning technologies should allow greater flexibility in supporting and enhancing learning experience.

In this paper, we will present the Flex-eL (Flexible e-Learning) system – a learning environment supported by workflow technology. We will also demonstrate how workflow technology can provide a more flexible learning solution.

## 2. Related Technologies

There are many research and commercial web-based educational products available in the market. The most popular ones include Lotus LearningSpace, WebCT, BlackBoard, TopClass, etc. Marshall University (1999), Jackson (1999). Most products provide two major types of tools: Learner tools and Support tools.

Learner tools include:
➢ Web browsing – multimedia, security, bookmarks, etc.

- ➢ Asynchronous sharing – email, newsgroup, file exchange, etc.
- ➢ Synchronous sharing – audio/video chat, whiteboard, virtual space, teleconferencing, etc.
- ➢ Student tools – progress tracking, searching, motivation building, etc.

Support tools include:
- ➢ Course – planning, managing, customizing, monitoring, etc.
- ➢ Course contents – instructional designing, presenting information, testing, etc.
- ➢ Data – marking on-line, managing records, analyzing and tracking, etc.
- ➢ Resource – curriculum managing, building knowledge, team building, etc.
- ➢ Administration – installation, authorization, registering, server security, etc.
- ➢ Help desk – student support, instructor support.

Generally, these products emphasize on learner tools such as web-based multimedia applications. Although several leading packages provide a wide range of powerful support tools for various aspects of course management, most of them are still "task-oriented" rather than "process-oriented". Some of their deficiencies can be identified as following:
- ➢ Tools are designed to support individual learning tasks rather than the learning process.
- ➢ There is no integration of technologies that support various aspects of the study process.
- ➢ Tools offered by educational packages are content-free resources and their adoption and integration into the study program relies on the experience of the course designer. That often results in the technology-centered learning process.
- ➢ Every educational package provides a limited set of tools. Inclusion of the new tools as they become available could be very difficult.
- ➢ Generally, the educational package is used to support several individual subjects through separate accounts or workspaces and no interaction between different "accounts" is possible.
- ➢ Tracking student learning progress is very difficult. There is very limit coordination between the study material and time management of the students.
- ➢ Monitoring study progress of individual students is often neglected.

From the above observations, we found most e-learning packages are composed with a number of tools to support various aspects of the study process. Some come with very comprehensive administrative and support tools for collaboration. However, integration of all technologies becomes more expensive when the number of tools is increased. That is why we need a suitable technology to scaffold the entire e-learning environment. We believe that integration enabled by workflow technology could provide a flexible and effective learning environment.

## 3. Workflow Technology

Workflow technology allows building business information systems that offer the right tasks at the right point of time to the right person along with resources needed to perform these tasks. It allows separating the process logic requirements from the application systems and implementing them through generic external workflow management systems.

Traditionally, workflow technology has been used in applications where process oriented nature of the applications is obvious, for example, insurance policy/claim processing, loan request handling, travel expense approvals, bug reporting and resolution, project proposal preparation, etc. Such applications are often high volume and follow similar repeatable processes.

Workflow management systems are designed to improve business processes by providing the technology to automate different aspects of business processes by routing work in the proper sequence, providing access to the data and documents required by the individual work performers, and tracking all aspects of the process execution. A workflow application can be viewed in three dimensions:
- ➢ Process – The business logic that capture the activities, their inter dependencies, and associated people and applications required to meet the underlying business goals.
- ➢ Organization – The organization dimension captures information about people and roles that are allocated tasks.
- ➢ Infrastructure – The networks of the computer systems and associated business applications.

A generic workflow product has five major functional components:

- ➤ **Process Definition Tool** is used to capture and create the process definitions that are used for enactment by the workflow engine. The process definitions are stored in the process definition repository.
- ➤ **Process Definition Repository** contains all necessary information about the process needed by workflow engine to execute.
- ➤ **Workflow Engine** interprets the process definition and controls the instantiation of processes and sequencing of activities, adding work items to the user work lists, and invoking application tools as necessary.
- ➤ **Worklist Handler** manages the interaction between workflow performers and the workflow enactment service.
- ➤ **Administration and Monitoring tools** are used to modify and monitor workflow execution.

When building a workflow solution, it is important to understand different process logic requirements of the application. The associated organizational roles and performers of the process activities must be clearly defined. Each person is identified as a unique performer and group of performers are categorized as roles. In a generic scenario, setting up a workflow solution requires a few steps. First, the business process is designed and analyzed using the process definition tool. A process model is defined as workflow graph containing tasks and workflow modeling structures. Tasks are associated with roles and applications. In second step, the process definition is stored into the workflow repository and made available for workflow enactment service. The third step is to configure the workflow related application data for a specific instance of this process and initiating it. A process model is instantiated for each specific instance of the process. At runtime, the performers query the workflow system to get their worklists. The worklists contain the tasks that have been assigned to them. In the case where a task is assigned to a group role instead of a single performer, all performers within the same role see the task on their worklists. Typically when the task is taken, its state is changed from "available" to "commenced". The user gets the access to the resources and applications associated with that specific task to work on. When the task is completed, its state is changed from "commenced" to "completed", and the worklist information in the workflow system is appropriately updated.

Workflow systems provide a simple approach for the users to get to the work that is needed to complete the business process requirements. Users can concentrate on working on allocated tasks while workflow technology provides the infrastructure to allocate the work and associated resources effectively and efficiently.


## 4. Flex-eL Concept

In this section we will explain the concepts behind delivering e-learning services through workflow technology.

The idea of utilizing workflow technology to manage the learning and teaching activities comes from the nature of study processes. In a typical university learning environment students come to university and enroll in a program, e.g., Master of Information Technology. To obtain a degree from a program, it is required that students complete a number of courses, e.g., Database System, Computer Architecture, etc. Each course contains a number of study and assessment modules, e.g., Study SQL, SQL Assessments, etc. Lecturers and tutors are responsible for the teaching the course modules. Courses are often offered within a certain period of time called "semester", and the duration of the semester is fixed. At this point, we will show how the learning environment is mapped to three dimensions of a workflow application:
- ➤ Process – The available courses are modeled in the form of process definitions containing a number of study/teaching activities.
- ➤ Organization – The study process involves different people performing different tasks. Students can be viewed as individual performers and a group of teaching staff can share the same role for managing a specific course.
- ➤ Infrastructure – The computes, study material, and other information needed to perform the process tasks form the infrastructure for the workflow based e-learning application.

We have found that there is a very logical mapping between e-learning application requirements and the workflow technology. Workflow technology offers many benefits that can potentially enhance e-Learning environment, such as:
- ➤ By automating the learning process it can potentially improve student/teacher productivity.
- ➤ Provide continuous monitoring to all users.
- ➤ Support for individual planing of work schedule as well as the resource.
- ➤ Working at individual's own pace, users has options of choosing preferred working pathways.
- ➤ Management of information and knowledge sharing.

➢ Collaboration between users.

One of our research goals has been to investigate the applicability of workflow technology in non-traditional workflow domains. The Flex-eL concept is one of such examples. Traditionally, the use of workflow technology has not been explored in e-learning solutions. However, our experience shows that workflow technology provides an innovative and flexible environment to deliver education courses. In particular, Flex-eL is focusing to achieve several specific objectives:
➢ Relax enrolment time constraints
➢ Remove predefined semester duration
➢ Assist in enforcing academic prerequisites
➢ Maintain high-quality subject content
➢ Provide flexible learning pathways
➢ Support innovative learning strategies
➢ Allow individual time management during study
➢ Encourage true collaboration and work in groups
➢ Provide access to personal teaching assistance
➢ Provide effective resource management
➢ Provide study progress monitoring capabilities

Flex-eL aims to support the concept of flexible learning pathways through subjects consisting of modules that, in turn, are managed by a number of learning activities. Our approach is to create student-centered learning that starts from the concept of the integrated study process that is carefully designed based on the latest educational models and supported by workflow technology. Effective integration of various learning activities is enabled by the study guide while workflow technology offers the right tasks i.e. learning activity at the right point of time to the student along with learning resources needed to perform these tasks. One of the main advantages of workflow technology, which is used as a backbone of Flex-eL, is to provide better integration of the new resources and new tools as they become available in the future.

## 5. Workflow Enabled Learning

Figure 1 shows the course structure offered in Flex-eL mode. Similar to the traditional university course structure, it has programs at the top level. A program is composed of a selection of courses. Each course is composed of a set of study and assessment modules. In the traditional approach, modules within a course are taught sequentially, one after another. But in Flex-eL, courses can be designed in a way so that modules can be performed paralleled or sequentially. This is a more flexible way of learning, and students can decide their own learning pathways. Consequently, we can design the course modules into a workflow process containing a number of study and assessment activities.
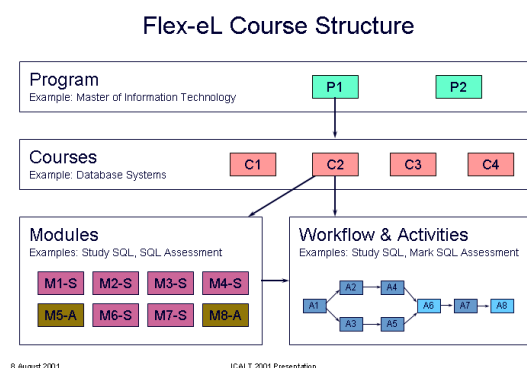


*Figure 1.* Flex-eL Course Structure

In the traditional learning environment, study/assessment modules have fixed durations and deadlines. There are a lot of time constraints in this approach. In some unforeseen circumstances, for example, illness, family commitment, etc. this approach means that some students will be unable to complete the course. Let us consider the typical e-learning approach as well. E-learning has removed the time and location constraints by taking the advantages from internet over classroom. However, most e-learning packages put all learning materials together

in a web based system with a few collaboration tools for teaching fellows and students. Generally there is no or very minimal coordination between the study material and teaching support. Students often do not know where to find assistance during study process. This approach still has the deficiencies in providing the right assistance to students and lack of monitoring. Figure 2 shows the Flex-eL's approach which extends the typical e-learning approach by keeping the necessary collaboration tools, plus assigning each student an individual learning process driven by workflow, so that the entire learning process can be monitored and guided.
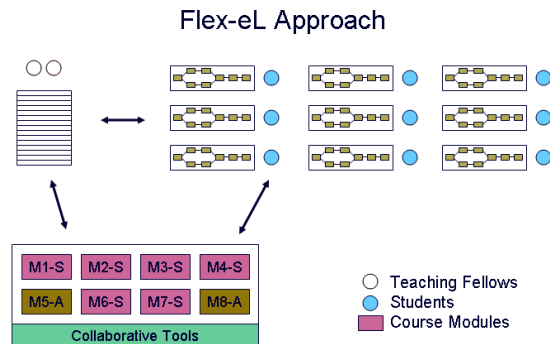


*Figure 2*. Flex-eL approach

A well-integrated study environment should include components such as learning and assessments into one fully system supported stream of activities. Workflow technology can then be used to manage these learning activities for different roles. The design of Flex-eL takes the workflow technology as the main backbone infrastructure and incorporates other technologies and tools around it to achieve a complete learning environment. Figure 3 shows the Flex-eL technology architecture.
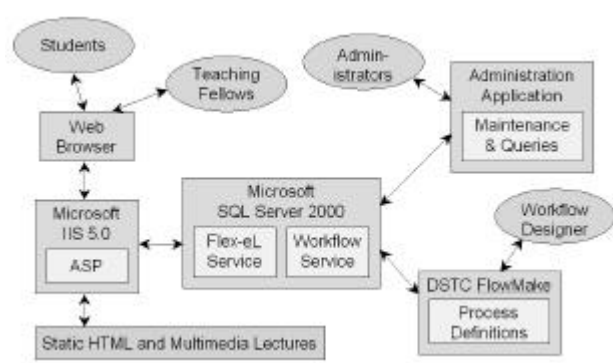


*Figure 3*. Flex-eL technology architecture

A process-modeling tool called FlowMake is used capture the study process. The course activities and associated roles are identified and modeled using the tool. This predefined workflow model is then deployed in the workflow repository which has been built upon Microsoft SQL server 2000. Flex-eL uses web interface to provide students and teaching fellows accessibility to the system. The study materials are presented in multimedia form. Flex-eL provides internal functionality to build study materials. However, it is also possible to link learning activities to any externally available learning material. The administration features allow setting up courses, enrolling students, and managing workflow processes.

When setting up a new course, we define the teaching staff in the database that are responsible for managing the new course and assign them a teaching fellow role for the new course. We then define the new course that includes creating study materials, defining tasks that need to be performed in the course, defining assessments, and scheduling assessment time slots. After that we model and export the associated process definition for coordinating the course into the workflow repository and link it with the course definition. For example, activities in the process model are associated with relevant study materials and performer roles. Exporting the process model in to workflow repository from FlowMake also includes generating the VML code for the course process visualization. The exported process model provides a process template for the course.

Whenever a student enrolls in a course, we create his information in the database if it does not already exist. After that, we enroll the student under the requested course. Finally, we start an instance of the learning process for the student based on the process template. This also means each student will have the same list of activities based on the same process template. It is also possible for having more than one process template for the same course. For example, one process template may have only a single assessment at the end of study period. Another process template may have smaller assessments during the study period. The teaching fellow and student can decide between themselves which type of process template would be suitable for the student.

In Flex-eL, each course is associated with one or more workflow process templates that define the order of course activities. One of these process templates is assigned to each student when he or she enrolls in the course. This is one of the Flex-eL's unique features that offer tailored learning pathways and flexible study styles for students. Each student can learn at their own pace, without worrying the deadlines for assignments and assessments. By relaxing time constraints the flexibility for individual time management is achieved. Flex-eL's learning strategy also has the potential to speed up the studying processes. Students could complete their courses as soon as they have finalized all the required tasks assigned to them by the system. As for teaching fellows, workload is also reduced because assessment and consultation times can be booked prior to the actual meeting. Overall, the learning and teaching effectiveness of courses is increased because of the more efficient and flexible time management.

Flex-eL offers a different learning approach than supported by other well-known online learning management systems. Rather than making all the course material and activities available to the student at the beginning of the course, Flex-eL coordinates their availability and completion by utilizing its embedded workflow functionality. When the appropriate learning or assessment activity is completed, a new activity is assigned to the work list of associated person.
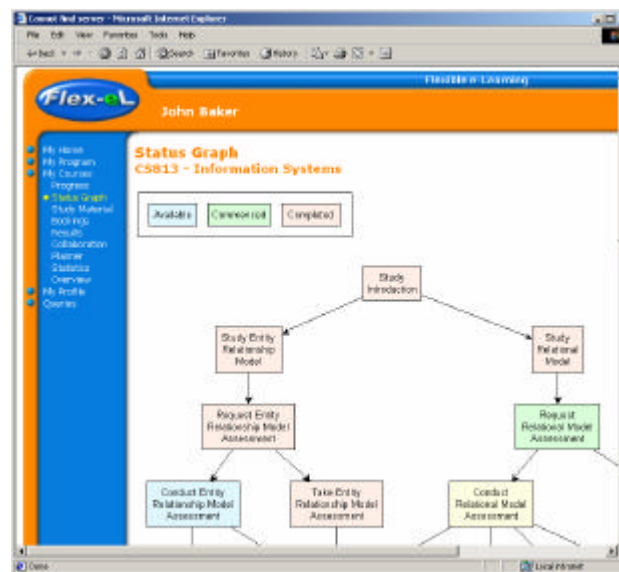


*Figure 4*. Flex-eL course status graph

During the study phase, the progress of each individual is captured by workflow system. Therefore, the students have the ability to find out the information about other students who are working on the same activity. Such features encourage collaboration among students. The teaching staff is also able to monitor the progress of individual students and may provide assistance to individual students. Flex-eL provides effective collaboration between students themselves as well as students and teaching staff. In contrast to the other online learning management systems that provide chat room or discussion boards for collaboration, Flex-eL helps to identify groups of people suitable for collaboration.

One of the unique features that Flex-eL offers is the monitoring of study progress through workflow visualization. Workflow visualization plays an important part in workflow systems. It provides the information necessary to understand the interactions between workflow tasks and the decision processes. One of the ways to visualize workflow progress is to use process model graph designed in the modeling tool as a basis for highlighting activities with appropriate status colors. Students can use this workflow functionality to visualize their current study progress and also plan for their future study pathways. Flex-eL uses VML (Vector Markup

Language) to display workflow diagram on web interface. The diagram is dynamically generated at run time at user request and uses difference colors to represent the state of each activity. This VML workflow visualization approach has the advantage of fast accessibility and ease for understanding. This approach also helps the teachers to monitor a students' progress at a glance.

## 6. Observations from Flex-eL deployment

We have successfully deployed Flex-eL at the University of Queensland for one postgraduate subject in the Master of Information Technology program and one undergraduate subject. One of the positive results of the deployment was that very few students dropped out from the course offered in the Flex-eL mode in comparison to other courses offered in the traditional mode. Because of the flexibility in time management and not having to attend the lectures, students were able to manage their workload effectively.

On the basis of our experiences, we have identified several technical and design improvements that are being introduced in the new version of Flex-eL. We have also made several observations that, we believe, will help us in deploying future courses in Flex-eL environment.

Design of the study process workflow is very challenging and critical. Although we aim to provide maximum flexibility to individuals study pathways, coordination between the teaching fellows and the students must be considered. For example, the assessment activity involves the contribution from both parties. The definition of completing this activity should be independent for both roles so that one could not delay the other proceeding to the next activity unnecessarily.

The definition of the atomic activity is crucial. It is important to define the most appropriate size for each activity, so that the users are not repeating of the same "available – commence – complete" cycle for unnecessary activities.

Another challenge is the preparation for students to adopt this kind of learning environment. As we provided a fully automatic self-learning system, we expect the students have basic web computer skills to use the system and it is their own responsibility to manage study time.

## 7. Conclusion

In this paper, we have described Flex-eL, an innovative and flexible learning environment supported by workflow technology. We have identified some deficiencies of current e-Learning systems and proposed the new approach to overcome some of the problems through workflow technology. We propose that a well-structured learning environment should integrate various aspects of learning by using the workflow technology. The underlying learning strategy of Flex-eL provides flexible learning pathways and possibly brings the virtual university concept closer to reality. We have also come across a number of challenges through the deployment of Flex-eL system. These experiences have helped us identify the issues that need to be addressed when deploying workflow enabled e-learning services.

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